APPENDIX P

RESTORATION MONITORING PLAN OUTLINE

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This appendix outlines the general protocols needed to evaluate whether the EE/CA aquatic and riparian habitat restoration objectives have been met and to evaluate the performance of a sorptive cap in the banks. The first portion of the appendix outlines the objectives and procedures for the monitoring of the aquatic and riparian habitat restoration. The second portion provides a brief description of the sorptive cap monitoring procedures assumed for the EE/CA.

P.1 EE/CA AQUATIC AND RIPARIAN HABITAT MONITORING

The aquatic and riparian habitat monitoring protocol is based on the following objectives: (1) prevent erosion of residual PCB-contaminated bank soils, (2) provide riparian cover and enhance the bank vegetation by reestablishing riparian plantings with native species, and (3) increase the diversity and productivity to support a midreach stream community. For each objective, the outline lists the monitoring parameters, performance standards (where applicable), methods, and schedules.

Performance standards are essential for monitoring plans as they give specific standards to use in evaluating the effectiveness of restoration efforts (e.g., increase percentage of pools to 30 %). Since some of the objectives are general (e.g., objective 3 listed above), detailed performance standards were not developed. The aquatic and riparian habitat restoration monitoring plan outline below presents an overview of the parameters that need to be included in the final monitoring plan. As future restoration plans become more fully developed, specific performance standards need to be incorporated into the monitoring plan. Elements of the aquatic and riparian habitat monitoring, such as observation of erosion or bed movement in the river, are important to and interrelated with the monitoring of the performance and long-term integrity of a sorptive cap.

A section on reporting for the habitat restoration monitoring should also be included in the final monitoring plan. This section will include when reports will be developed, what will be presented, and to whom the reports will be sent. The reports need to summarize whether the objectives are being met and what follow-up action (e.g., maintenance) is necessary to achieve the restoration objectives. Generally, reports are to be summarized annually, but may need to be completed more frequently depending on the performance standards.

I. Prevent Erosion of PCB-Contaminated Soils

Overall objective: Prevent erosion of residual PCB-contaminated soils from both the bed and bank.

A. Visual Inspections

1. Riverbed restoration structures

A. Structure stability

Assess each in-stream structure and determine its stability (e.g., boulder movement, undermining). Use as-built condition for comparison. Estimate repair needed, if any.

B. Erosion

Assess whether there is local erosion occurring at each structure. Estimate extent and whether it is detrimental. Estimate repair needed, if any.

C. Upstream/downstream effects

Assess any upstream or downstream effects (e.g., erosion of streambank) that may be occurring as a result of the in-stream structures. Estimate extent and whether it is detrimental. Estimate repair needed, if any.

2. Streambank restoration structures

A. Slope stability

Assess each streambank restoration structure and identify any slope movement (e.g., slumps) and potential slope failure areas (e.g., undermining of bank), and inspect structural integrity of restoration elements (e.g., structural changes of retaining wall). Estimate repair needed if any.

B. Surface erosion

Assess whether there is local erosion occurring at each structure. Estimate extent and whether it is detrimental. Estimate repair needed if any.

B. Long-Term Erosion Transects

1. Reference channel cross sections

Use existing USACE channel cross-section locations to select long-term monitoring sites. Selected sites should include a range of geomorphic units (e.g., pools, riffles, bends, etc.) and cover both the riverbed and streambank. Determine cross-sectional area. Assess changes in area over time. Using information from all stations, estimate overall changes in EE/CA Reach.

2. Sediment characterization

At each reference cross section, measure bed substrate. Calculate sediment size characteristics (e.g., D_{50}). Assess changes in bed substrate over time.

C. Monitoring Tasks

1. Photographs will be taken for both visual assessment and channel cross sections.

2. Erosion sites, in-stream structure locations, and channel cross sections will be measured and mapped.

3. Sediment characterization: Characterize bed sediments using standard Wolman pebble count (99-0235) or other appropriate procedures.

D. Monitoring Schedules

1. Monitoring visits will occur annually for the first 5 years, then every 5 years for the remainder of the monitoring period (up to 20 years) for both visual inspections and channel transect measurements. If a flood event of Q_{10} or larger occurs, then monitoring will occur that year (up to 20 years).

II. Establish Riparian Vegetation

Overall objective: (1) Provide cover and enhance the bank vegetation by reestablishing plantings, and (2) increase the diversity and productivity to support a midreach stream community.

A. Riparian Habitat

Short-term objective: Establish vegetative cover in areas of exposed soils within the restoration area (i.e., the excavated areas from the edge of channel to the top of the stream bank). The short-term objectives have been formulated for the first 1 to 5 years after the initial restoration measures are implemented.

Long-term objective: Promote the establishment of a diverse assemblage of native riparian plant communities similar to those that existed before remedial activities took place in these areas. The long-term objectives generally refer to a period of 20 years.

1. Vegetative Cover – Percent Cover of Dense Vegetation

Within 2 years after planting and seeding, the restoration areas will be vegetated to minimize the potential for soil erosion. For the purposes of this standard, dense vegetative cover is defined as more than 70% areal coverage of the riparian zone.

2. Diversity of Plant Species

Within 5 years, the restoration areas will exhibit plant species diversity similar to what existed before the remedial action. Diversity will likely be compared to other areas of the Housatonic River.

3. Survivorship of Planted Woody Stock

Where the restoration areas are planted at least 80% of the installed shrubs and trees must survive and be growing vigorously 3 years after the initial planting. Volunteer woody plants will also be counted toward meeting the specified initial planting densities (700 to 750 plants per acre).

4. **Percent Canopy Cover Over Stream**

Within the long-term monitoring period the canopy cover over the stream in the restored areas will be similar to what existed before remedial action was taken. Percent areal cover data collected before excavation will be used as a comparison.

5. **Invasive Species**

No greater than 5% of the restored area will contain invasive species such as phragmites (*Phragmites autralis*), purple loosestrife (*Lythrum salicaria*), Japanese knotweed (*Polygonum cuspidatum*), Morrow's honeysuckle (*Lonicera morowii*), winged euonymous (*Euonymous europaea*), Japanese barberry (*Berberis thunbergii*), Russian olive (*Elaeagnus angustifolia*), and Asiatic bittersweet (*Celastrus orbiculatus*). Specific criteria used to judge whether the invasive species is becoming detrimental will include: (1) the rate of spread; (2) the type of habitat; (3) the extent of habitat conversion as a result of the invasion; and (4) the overall percentage areal cover of the invasive species within the habitat unit.

B. Monitoring Methods

Monitoring will primarily include annual assessments of planted stock, vegetation density, and soils.

1. Sample plots: Natural community sample plots will be established to characterize and measure vegetation and soils within restored areas. Permanent sample plots will be established at specified points. Plots will measure 10 meters by 10 meters with nested subplots.

2. Meander surveys: Meander surveys will be conducted during each visit to assess the overall vegetative and soil conditions. The meander surveys will supplement sample plot data, and will involve walking random routes throughout the restoration area to identify problems such as significant plant mortality, occurrence of invasive species, and erosion.

3. Overall distribution and survivorship of planted stock will be assessed during each visit by comparing on-site conditions with as-built specifications.

4. Representative photographs of the restoration areas from established locations will be taken annually to facilitate a yearly comparison.

C. Monitoring Schedule

Due to the nature of the communities being replaced, full realization of the long-term objectives will take many years. For example, the overstory and understory components of riparian habitat will not be fully developed for at least 20 to 25 years. However, it is expected that the long-term outcome will be predictable after 5 to 10 years of monitoring.

1. Monitoring visits will occur three times a year for the first 3 years, twice a year for the next 2 years, then once a year for the remainder of the monitoring period (up to 20 years).

2. The first 3 years of monitoring will include a spring site visit to assess the general condition of the restoration areas and to check for significant winter damage. Another site visit will be conducted in the middle of the growing season to collect detailed information on vegetation and soils. A third site visit will be conducted in the fall to identify corrective measures that may be needed the following year (i.e., replanting, erosion control).

3. For years three and four, only the spring and mid-season site visits will be conducted.

4. For the remainder of the monitoring period (up to 20 years), an annual visit will be conducted during the growing season.

5. Once vegetation becomes well established, it is anticipated that the site will maintain itself without the need for long-term management intervention.

III. Enhance Aquatic Habitat

Overall objective: To enhance in-stream habitat that allows fish and invertebrates to recolonize naturally, and ultimately increase the species diversity and productivity to support a stream ecosystem. The restored stream channel must be able to support fish, macroinvetebrates, and other aquatic organisms. Restoration success will be based on the following physical and biological parameters:

Physical Parameters: The restored stream channel must contain a variety of habitat components. These include pools, riffles, substrate, cover (predation, hydrologic, etc.), a variety of channel widths and depths, food sources, flow patterns, water quality (e.g., temperature, chemistry), and woody debris (if possible). Success will be evaluated on the quantification of these habitat components (e.g., standard deviation of depth, average channel width, substrate size). Professional judgment will also be needed to assess the qualitative components (e.g., complexity of pool habitats).

Biological Parameters: The overall physical parameters must support viable populations of fish and other aquatic life. Presence/absence of fish and macroinvertebrate surveys will be conducted to assess these parameters. Recolonization of the restored stream reaches by fish and invertebrates will be allowed to occur naturally.

A. Monitoring Methods

1. Aquatic habitat surveys will be conducted. Habitat types and sizes, substrate, cover, channel geometry, etc., will be quantified using a detailed stream survey protocol (e.g., Hankin-Reeves stream survey). Reference photographs will also be

established. This assessment will be compared to pre-restoration conditions to evaluate whether habitat restoration objectives have been met.

2. Position of habitat units and associated features in the restored stream will be located. A plan-view map, which illustrates the location of habitat types for the entire EE/CA Reach, will be produced.

3. Rapid Bioassessment Protocol (RBP) macroinvertebrate community surveys will be conducted to assess the structure and diversity and numbers of individual species present at a given location.

4. Rock basket or rock bag sampling will be conducted and the resulting macroinvertebrate community data will be used to determine compliance with the Commonwealth of Massachusetts Water Quality Classification for that given reach of the stream.

5. Water quality stations will be established at the upstream and downstream ends of the EE/CA Reach. Parameters include water temperature, conductivity, pH, and dissolved oxygen.

B. Monitoring Schedules

1. The overall condition of the restored stream will be assessed during each site visit.

2. Wildlife Usage Stream habitat surveys will be conducted after the initial restoration and thereafter in the third, fifth, and tenth years.

3. The viability of macroinvertebrate communities and fish within the restored area will be monitored annually for the first 3 years after the initial restoration, and again in the fifth and tenth years.

4. Water quality data will be collected daily and summarized annually for the entire monitoring period.

IV. Enhance Wildlife Habitat

Overall objective: To restore the stream and riparian habitat to a level that will support terrestrial wildlife species that use stream and riparian habitats (i.e., songbirds, waterfowl, shorebirds, small mammals, furbearers, etc.)

1. **Wildlife Usage**. Within the first year of the initial restoration of the stream and riparian habitat, wildlife will inhabit these areas.

A. Monitoring Methods

1. Meander Survey: Meander surveys will be conducted to assess the presence and absence of wildlife species.

B. Monitoring Schedule

1. Data on general wildlife use will be collected during each site visit, at sample plots, and during meander surveys. Actual wildlife sightings and observed signs will be recorded by species and presented in a list for a general year-to-year comparison.

P.2 SORPTIVE CAP PERFORMANCE MONITORING

Monitoring of the performance of a sorptive cap installed in the lower banks is critical due to the fact that the cap will be installed within a dynamic river environment. The objective of the sorptive layer would be to retard the movement of PCBs in the lower banks into the clean backfill material placed after the EE/CA Reach removal action, and into the river water column. The key elements of the monitoring of the sorptive cap are evaluation of cap physical integrity and PCB transport within the cap over time.

For the purposes of the EE/CA, monitoring of cap physical integrity can be incorporated into the monitoring of riverbank erosion described in the outline above for aquatic and riparian habitat restoration. Monitoring of cap performance would involve coring and testing the cap material at time intervals of 1, 5, 10, and 20 years after completion of construction and restoration. A total of eight cores of the sorptive cap would be obtained (two in each subreach where capping is conducted). Each core would be segmented into 2-inch sections (six total for each core assuming a 1-ft-thick sorptive cap), and each section would be analyzed for PCBs and TOC.

The results of the cap testing, the findings and conclusions regarding the observed contamination profile within the cap compared to the modeling results, and the aquatic and riparian habitat monitoring results would be presented in the annual monitoring report.